RAPID MANUFACTURING SYSTEM: 21ST CENTURY MAINTENANCE TECHNOLOGY

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Introduction

The Army is faced with many maintenance challenges that impact readiness. An aging legacy fleet combined with a new emerging fleet poses support and sustainment challenges that cannot be met using traditional technology and methods. The Mobile Parts Hospital is a program that seeks to address some of these challenges. As the program has evolved, it is now being referred to as the Rapid Manufacturing System (RMS). The RMS is a mobile manufacturing system that can produce parts rapidly near the point of need in the battlespace.

The RMS currently consists of two 8- by 8- by 20-foot containers, each carrying one piece of manufacturing equipment. The first is a Directed Material Deposition (DMD) machine that uses a patented process called Laser-Engineered Net Shaping (LENS). The DMD machine can create a fully dense metal part from a computer-aided design (CAD) model. After a part is built "near net shape" in this machine, it goes to the other machine—a 5-axis multitask machining center produced by Mazak for final finishing and dimensioning.

When a request for a part comes to the RMS, its onboard databases are searched to determine if that specific part or one similar to it has been built before. To make the part, the RMS must have a complete 3-D model of the requested part. If the information is not available in the databases, onboard equipment is used to create it—either through a CAD/computer-aided manufacturing (CAM) software package or through a noncontact laser scanner. Once a 3-D model is obtained, it is converted to a file format used by the first of the manufacturing processes described below.

LENS Machine

The first International Standards Organization (ISO) container of the RMS contains a LENS machine. The LENS process is considered a DMD process because powdered metal is directed into the path of a laser beam to create a part layer by layer. The metal parts created using this process can be made equivalent (and possibly better) than the original part in terms of material properties. Also, the time to create a part using this process, compared to casting or forging, is greatly reduced. This is the greatest advantage of the LENS machine.

The LENS process is still immature and remains under both development and testing. To be of use to the RMS, there are many variables in the process that need to be thoroughly understood. The RMS team has laid out three distinct experiments to explore and understand how each of the process variables contributes to the final material and the resultant mechanical properties.

Currently, there are 57 metal powders available for use in the LENS machine, and they cover the spectrum from steel to alloys to titanium. The intention is to carry a powdered metal to the battlespace rather than multiple sizes and shapes of traditional bar stock. The LENS machine will create the rough part from the powder. The rough part will then be finish-machined on the multitask machining center.

Machining Center

The second container of the RMS contains a 5-axis multitask machining center. These machines are multiaxis mills that are set up primarily as lathes. Work pieces such as gears and camshafts that normally would require separate turning centers, and both vertical and horizontal machining centers, can now be completely machined with efficiency and accuracy. All axes are direct motor driven with no belts, pulleys, or gears, and tool exchange speed is nearly instantaneous.

The machine incorporates a color graphics display and a simple programming language. Rather than having to input direct machine code, the programmer simply inputs the dimensions in a logical machining sequence (guided by the machine), and the video display unit shows a shaded model of the work piece for each stage, including a model of the cutting tools in action. This can be seen dynamically for an entire program prior to cutting material and while the actual machining is in progress.

The machine is capable of making tool-path adjustments on the fly to compensate for tool wear. Any manual adjustments done by the operator while the program is running can be recorded by the controller and immediately incorporated into the master program file, if desired. Another capability of this machine is the ability to record cutting-path data in the event of a tool breakage. This information is recorded as the operator manually guides the tool away from the work piece for changing. At the restart command, the stored cutting path data guide the tooling back to the interrupted stage position, and the original program continues. There is no need to return to the program beginning, so this offers significant timesavings over conventional methods.

RMS

The proposed unit to be fielded is just one part of a system-of-systems that will comprise the RMS. There are communications, parts databases, and agile manufacturing cells that are all linked to the mobile systems to provide spare parts to the soldier within hours.

The first supporting element is the parts database, managed by a software package called WindChill. Producing parts on demand with a CAD/CAM data library provides a distinct advantage in timeliness because the entire reverse engineering step can be eliminated. However, if reverse engineering is required, there is a 3-D laser scanner onboard the mobile system, along with software to support reverse engineering. The RMS continually identifies and adds parts to this database by gathering or creating the manufacturing data. The Standard for Exchange of Product format is the current, universally adaptable CAD language and manufacturing data format of choice and is being used by the RMS.

The RMS also contains a satellite data transfer system for receiving and sending CAD/CAM data from anywhere in the world. This data can be directly fed into either of the manufacturing machines or into the pro-engineering workstation for further model definition and storage.

The U.S. Army Tank-automotive and Armaments Command's (TACOM's) Tank Automotive Research, Development and Engineering Center in Warren, MI, is a likely location for the command and control center, which will network the eventual RMS fleet and agile manufacturing cells. The central parts CAD/CAM database and raw material procurement would be logically handled in a central location. Tentative plans are to merge the RMS command and control activities with those of the Emergency Operations Center already located at TACOM.

Although the mobile system of the RMS is successful for a wide variety of parts, it has definite size and weight restrictions, which lead to process limitations. Several critical parts have manufacturing requirements that are simply too large or impractical for a mobile setting. An agile manufacturing cell will be an integral partner to the RMS and will be the support system capable of handling these larger repair parts and processes not available in a mobile unit.

Currently, Army personnel must bring a warehouse of parts with them everywhere they go for all the vehicles they use. With this new RMS, the only supply chain demand is buckets of powder for the LENS machine. This would reduce both the cost and the time associated with buying the spare parts and storing and keeping track of them. It truly exemplifies the Army's goal to reduce the cost and size of the logistics tail while increasing combat commander effectiveness.

Conclusion

The RMS is taking manufacturing in a new direction. Today, even the best rapid prototyping and manufacturing processes are inadequate to fulfill the requirements of the RMS Program, but several processes have made great strides in recent years. In the future, the RMS Program will incorporate processes that offer a wider range of materials, faster build rates, and greater accuracy. The RMS Program must work closely with the Army Ordnance School and the Army Quartermaster School to understand the process and work together to improve vehicle readiness while reducing costs.

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